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Some Factors Affecting the Weight of Eggs

(Technical)

By

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Some Factors Affecting the Weight of Eggs

Other things being equal, the food value of an egg is practically in direct proportion to its weight. Therefore, it is important to know the factors that tend to influence the size or weight of eggs. The size or weight of eggs is also of importance to the breeder since, other things being equal, the big egg hatches out the big lusty chick. Moreover, it is probably true that the same factors which bring about fluctuations in egg weight influence the number of eggs that a hen may lay, hence a knowledge of the causes which bring about variations in weight may be of value in throwing light on the process of egg production, and thus aid in the development of better methods of feeding and managing laying hens.

BRIEF REVIEW OF LITERATURE

It may be well to review briefly the observations and experiments which have been reported in experiment station publications with reference to egg weight.

Effect of Age of Laying Stock on Weight of Eggs

The age of the bird laying the egg has a marked influence on its weight. It is well known that pullet eggs are smaller than the eggs laid by mature fowls. Dryden (1900) found that the eggs laid by yearling White Leghorn hens averaged 8 per cent heavier than the eggs laid by the same birds during the pullet year. Hadley and Caldwell (1920) using White Plymouth Rocks found an average increase in the weight of the eggs of from 4 to 6 per cent from the first to the second laying season. Atwood (1925) with White Leghorns found an average increase from the first to the second laying season of about 11 per cent, and a further increase from the second to the third laying year of about 2 per cent. Lippincott (1921), Atwood (1923), and Jull (1924) found that the younger the pullets when beginning to lay the smaller were the first few eggs that were laid.

Weight of Eggs as Influenced by the Breed

The size of the egg is a breed characteristic. At one extreme stand the bantams with their small eggs and at the other are the Minorcas and Brahmas. Gilbert (1891) found that Barred Plymouth Rock and Black Minorca eggs average 1.69 pounds per dozen; Brah-

ma eggs 1.81 pounds; White Leghorn eggs 1.63 pounds; and Wyandotte eggs 1.56 pounds per dozen. Dryden (1899) gave the average weight of Light Brahma eggs at 1.64 pounds per dozen and Brown Leghorn eggs at 1.46 pounds. The same author in Bulletin 67 of the Utah Experiment Station gave the weight of White Leghorn eggs (mature fowls) at 1.56 pounds per dozen, White Leghorn pullets at 1.37 pounds, Wyandottes at 1.56 pounds, and Barred Plymouth Rocks at 1.52 pounds per dozen. Stewart and Atwood (1900) report the mean weight of eggs laid by mature White Leghorn hens at 1.43 pounds per dozen. Card and Kirkpatrick (1919) in summarizing the results obtained from five laying contests in which a large number of different pens participated found that the Plymouth Rock eggs averaged 1.56 pounds per dozen; the Wyandotte eggs 1.47 pounds; the Rhode Island Red eggs 1.57 pounds, and the White Leghorn eggs 1 51 pounds per dozen. The figures obtained from the laying contests probably fairly represent the weight of the eggs of the four principal breeds as they exist today, although it is probably true that certain strains of the same breed may differ as much as the breeds themselves.

Weight of Eggs as Influenced by the Ration

A ration that is not fed liberally enough reduces the size of the eggs. Atwood (1914) found that a ration fed too sparingly may reduce the general size of the eggs as much as 2.6 per cent; also that if a fowl is fed an improperly balanced ration the size of the eggs will be decreased. Additional data along this line are presented later in this publication.

The Effect of Confinement on Egg Weight

Gilbert (1891) found that the eggs laid by hens in confinement were not so large as those laid by the same hens when they had free range. Whether this result was due to the additional exercise or to some other factor is impossible to determine as Atwood (1922) in one case found the eggs larger and in another case slightly smaller as the result of confinement. The additional exercise resulting from running at large when taken in connection with a more perfectly balanced ration which frequently accompanies free range may be the means of increasing the egg weight.

Seasonal Variation in the Weight of Eggs

The seasonal distribution of egg weight with pullets is quite different from that of mature fowls. In the case of pullets under

normal conditions there is a constant and fairly uniform increase in egg weight from the beginning of the laying period, say in December or January, till the close of the laying year. This increase in egg weight is closely correlated with the increase in the body weight of the birds. In the case of mature fowls, however, the maximum mean egg weight is in December and January and the minimum is in June and July, the mean egg weight for any particular month being in inverse proportion to the number of eggs laid during that month. In other words, the more eggs laid by mature fowls during any particular period the smaller they tend to become for that period as shown by Atwood (1923).

Inheritance of Size of Eggs

Laurie (1912), Benjamin (1920), and others have found that the size of eggs does not appear to be sex limited. That is, either parent will transmit. In mating stock for egg production the tested hens selected should be layers of eggs of the size required, and should be the progeny of hens which laid eggs of similar size, and of cocks descended from hens which laid eggs of the desired size.

THE MEAN WEIGHT OF THE EGGS LAID BY BIRDS OF THE SAME VARIETY

In connection with experiments reported in bulletins 179 and 182 of this station the following data on egg weight have been obtained.

Fowls Employed

The fowls employed in this experiment were standard bred Single Comb White Leghorns. Prior to the beginning of this experiment this strain of fowls had not been trapped or bred for egg production. From the standpoint of the weight of eggs these fowls may be considered as a random sample of Single Comb White Leghorns. Each female in flock A had one or more full sisters in flock B and vice versa. Likewise the birds in flocks C and D were sisters and E. and F were sisters. Flocks A, C, and E were well fed while young; flocks B, D, and F were fed rations low in protein and ash so that the increase in live weight was slow. After laying began all six flocks were fed uniformly on a well balanced laying ration.

The data used in this discussion cover three years' of production for flocks A and B, two years' for flocks C and D, and one year's production for flocks E and F. The laying year in all cases began December 1 and ended November 30. All eggs were weighed early each morning on the day following that on which they were laid, and in this discussion double yolked eggs and those abnormally small were disregarded. Most of the eggs were weighed on a chainomatic balance and the weights were recorded to one one-hundredth gram.

Tables 1, 2, 3, 4, and 5 show the number and the mean weight of the eggs laid by each bird. These tables are summarized and combined in Tables 6, 7, 8, and 9.

TABLE 1.—Number and Mean Weight of Eggs; Flock A, Well Fed While Young.

Band No. of Bird	FIRST YEAR		SECOND YEAR		THIRD YEAR	
	Number of Eggs Laid	Mean Weight of Eggs	Number of Eggs Laid	Mean Weight of Eggs	Number of Eggs Laid	Mean Weight of Eggs
301	146	49.38±.20	178	54.38±.14	148	55.29±.12
302	187	51.77±.17	192	58.13±.10	184	58.01±.12
308	56	49.38±.19	164	53.64±.12	123	54.70±.14
309	184	50.64±.18	133	58.03±.14	115	59.09±.20
311	180	50.68±.19	165	59.71±.11	145	59.57±.12
313	166	52.08±.18	176	56.72±.17	84	58.37±.13
315	164	52.73±.25	197	57.08±.11	146	56.23±.19
320	118	46.48±.17	103	52.29±.17	82	54.77±.26
322	165	50.69±.15	156	57.92±.13	152	58.01±.13
324	156	49.45±.14	135	55.21±.13	122	56.33±.11
325	162	49.03±.17	144	57.40±.14	140	58.59±.14
326	132	53.10±.19	142	56.21±.24	140	57.34±.18
327	149	53.91±.34	166	57.20±.17	168	57.29±.13
330	84	49.49±.24	153	55.97±.12	133	56.49±.17
331	165	51.39±.15	108	57.14±.11	135	56.93±.12
332	177	52.50±.26	140	59.52±.15	145	59.27±.13
333	140	49.55±.17	98	54.85±.22	111	54.77±.18
336	122	46.08±.18	134	51.46±.12	129	51.33±.22
342	169	49.98±.13	164	56.70±.13	137	58.19±.18
347	130	49.25±.24	133	54.45±.17	159	54.73±.14
351	109	48.56±.21	171	53.23±.16	151	52.44±.20
355	170	50.19±.18	179	58.77±.16	162	59.58±.21
356	150	46.17±.26	158	49.49±.13	167	50.96±.13

TABLE 2.—Number and Mean Weight of Eggs; Flock B, Poorly Fed While Young.

Band No. of Bird	FIRST YEAR		SECOND YEAR		THIRD YEAR	
	Number of Eggs Laid	Mean Weight of Eggs	Number of Eggs Laid	Mean Weight of Eggs	Number of Eggs Laid	Mean Weight of Eggs
303	94	50.78±.22	155	55.67±.21	117	54.74±.20
304	112	42.27±.18	158	48.91±.13	105	50.14±.17
305	180	48.95±.15	132	54.51±.14	133	55.05±.14
306	187	57.18±.27	156	64.65±.17	85	64.36±.28
312	83	52.50±.20	93	57.89±.26	80	58.00±.26
314	140	51.94±.20	133	59.45±.10	119	58.70±.11
316	138	51.54±.25	180	56.25±.13	163	56.35±.16
319	163	50.00±.23	162	54.15±.12	144	55.50±.15
323	183	48.66±.20	181	55.13±.13	144	54.51±.15
329	100	53.43±.16	141	60.88±.14	124	62.76±.20
334	126	49.94±.14	146	53.47±.15	151	52.68±.13
335	111	52.46±.17	166	60.14±.14	144	59.97±.16
337	97	52.30±.38	137	54.70±.17	144	55.99±.16
338	93	48.24±.16	134	51.61±.14	148	52.35±.13
340	74	49.95±.20	154	54.96±.18	153	55.23±.16
341	106	50.78±.25	177	56.09±.15	156	56.52±.15
345	132	53.16±.18	171	59.12±.12	144	59.97±.12
348	78	51.74±.24	135	57.16±.14	72	57.19±.18
350	72	48.81±.28	132	52.52±.15	150	55.37±.16
352	135	47.59±.18	152	52.47±.14	109	52.12±.13
354	143	51.68±.15	156	55.31±.14	135	56.03±.17

TABLE 3.—Number and Weight of Eggs; Flock C, Well Fed While Young.

Band No. of Bird	FIRST YEAR		SECOND YEAR	
	Number of Eggs Laid	Mean Weight of Eggs	Number of Eggs Laid	Mean Weight of Eggs
401	148	48.28±.24	143	53.98±.15
402	149	52.51±.22	162	59.52±.16
403	123	53.02±.25	155	60.07±.15
404	111	51.20±.22	148	56.40±.15
406	108	49.55±.21	145	53.23±.13
407	125	50.54±.22	153	57.43±.13
409	156	52.70±.30	133	60.73±.18
411	108	52.37±.30	151	57.24±.14
415	134	45.75±.17	129	51.47±.15
419	150	50.16±.14	156	54.53±.15
420	155	52.93±.18	122	57.58±.15
421	150	48.12±.13	154	52.05±.10
422	82	52.26±.24	89	56.30±.19
424	203	51.82±.23	173	58.98±.13
428	124	52.53±.17	172	59.62±.16
431	133	51.51±.20	152	56.92±.13
432	146	52.77±.17	158	60.84±.18
434	147	50.30±.14	114	53.30±.16
435	208	52.94±.19	179	57.54±.12

TABLE 4.—Number and Mean Weight of Eggs; Flock D, Poorly Fed While Young.

Band No. of Bird	FIRST YEAR		SECOND YEAR	
	Number of Eggs Laid	Mean Weight of Eggs	Number of Eggs Laid	Mean Weight of Eggs
405	97	50.74±.26	132	56.79±.20
408	135	46.69±.25	120	51.75±.23
410	136	58.85±.20	139	64.40±.20
413	107	49.54±.28	84	54.14±.15
416	112	50.54±.16	159	53.30±.12
418	140	48.65±.15	164	55.09±.11
423	125	49.82±.23	124	53.22±.15
425	157	50.21±.19	109	54.84±.23
426	110	48.69±.20	182	53.13±.12
427	168	48.76±.16	168	52.79±.12
429	79	52.09±.16	144	55.31±.14
436	158	50.95±.17	214	52.34±.15
437	125	51.16±.27	129	53.88±.18
438	140	50.76±.18	120	54.44±.12
439	186	50.73±.14	141	55.44±.13
440	112	50.84±.21	121	55.33±.21
441	119	47.25±.19	158	50.80±.13
442	120	52.88±.21	155	58.26±.17
443	60	47.43±.40	139	48.76±.18

TABLE 5.—Flocks E and F; Pullet Year; Flock E, Well Fed While Young; Flock F, Poorly Fed while Young.

FLOCK E			FLOCK F		
Band No. of Bird	Number of Eggs Laid	Mean Weight of Eggs	Band No. of Bird	Number of Eggs Laid	Mean Weight of Eggs
500	150	51.52±.14	550	170	49.72±.20
501	129	50.43±.17	551	139	55.47±.17
502	148	51.49±.15	552	160	52.92±.15
503	134	54.22±.19	553	138	54.15±.16
504	174	53.25±.16	554	70	51.46±.12
506	188	54.45±.18	555	149	52.65±.20
507	180	52.74±.14	557	113	53.22±.17
508	98	54.76±.20	558	185	49.10±.12
510	118	52.68±.19	559	181	51.19±.17
511	147	52.83±.15	560	145	53.99±.18
512	99	49.94±.22	561	153	54.17±.12
513	158	48.37±.15	562	127	52.48±.12
514	186	50.13±.17	563	172	53.32±.15
515	166	52.35±.14	565	174	57.63±.14
516	132	50.63±.11	566	153	54.66±.17
517	167	53.73±.17	567	70	45.13±.35
518	138	54.02±.15	568	200	53.68±.12
519	193	48.81±.11	569	140	55.99±.16
520	183	50.06±.14	570	145	52.99±.10
521	167	50.57±.13	571	151	46.42±.11
522	176	49.06±.10	572	132	54.84±.14
523	172	53.70±.18	573	101	47.90±.25
524	165	54.43±.17	574	107	57.08±.16
525	108	52.53±.14	575	141	55.38±.13
526	174	51.10±.15	576	121	49.42±.15
527	182	50.47±.18	577	145	52.80±.18
528	152	56.39±.14	578	154	48.62±.18
529	189	51.07±.15	579	160	50.31±.18
530	186	48.41±.13	580	125	51.50±.14
532	137	47.49±.21	581	142	46.54±.15
533	121	53.34±.13	582	76	50.49±.25
534	159	51.35±.17	584	145	48.41±.14
535	182	51.92±.16	585	123	53.76±.18
536	171	50.42±.13	586	176	49.49±.16
537	143	55.43±.16	587	146	55.21±.17
538	160	53.86±.22	588	130	51.25±.18
539	139	49.02±.21	589	155	50.49±.14
540	164	50.68±.22	590	147	50.49±.16
541	148	52.18±.12	591	165	50.42±.15
542	160	50.49±.18	592	126	52.77±.19
543	178	52.11±.14	593	105	47.28±.16
544	115	48.34±.26	594	183	45.73±.11
545	157	53.76±.14	595	121	51.80±.15
546	174	50.54±.10	596	137	56.12±.16
547	149	48.50±.20	597	179	50.56±.16
548	165	51.79±.15	598	109	48.75±.19
549	155	51.77±.13	599	53	50.46±.28
			600	40	57.40±.33

TABLE 6.—Summary of Results With Hens Well Fed While Young.

Flocks	Year	Number of Fowls	Mean Number of Eggs	Mean Annual Weight of Eggs	Standard Deviation in Number of Eggs	Standard Deviation in Mean Annual Egg Weights	Mean Standard Deviation in Weight of Eggs
A	First	23	147.00±4.47	50.12±.29	31.8±3.16	2.04±.20	3.53±.13
A	Second	23	151.69±3.65	55.90±.36	26.0±2.58	2.54±.25	2.61±.08
A	Third	23	138.17±3.40	56.47±.35	24.2±2.41	2.46±.25	2.72±.05
C	First	19	140.00±4.58	51.12±.30	29.6±3.23	1.95±.21	3.57±.13
C	Second	19	146.68±3.28	56.72±.44	21.2±2.32	2.83±.31	2.63±.05
E	First	47	155.75±2.34	51.67±.20	23.8±1.65	2.04±.14	3.00±.06

TABLE 7.—Summary of Results with Hens Poorly Fed While Young.

Flocks	Year	Number of Fowls	Mean Number of Eggs	Mean Annual Weight of Eggs	Standard Deviation in Number of Eggs	Standard Deviation in Mean Annual Egg Weights	Mean Standard Deviation in Weight of Eggs
B	First	21	121.29±5.15	50.62±.42	35.0±3.64	2.84±.30	3.37±.13
B	Second	21	150.05±2.97	55.97±.51	20.2±2.06	3.47±.36	2.69±.07
B	Third	21	129.52±3.77	56.36±.50	25.6±2.66	3.38±.35	2.73±.07
D	First	19	125.06±4.87	50.35±.40	31.5±3.44	2.56±.28	3.41±.10
D	Second	19	142.21±4.36	53.89±.51	28.2±3.08	3.28±.36	2.74±.12
F	First	48	137.40±3.33	51.76±.30	34.2±2.35	3.12±.21	2.80±.05

Table 8.—Summary of Results With Hens Well Fed While Young; Flocks Combined by Years.

Flocks	Year	Number of Fowls	Mean Number of Eggs	Mean Annual Weight of Eggs	Standard Deviation in Number of Eggs	Standard Deviation in Mean Annual Egg Weights	Mean Standard Deviation in Weight of Eggs
A. C, E	First	89	150.12±2.00	51.15±.15	28.1±1.42	2.12±.11	3.26±.06
A. C.	Second	42	149.43±2.51	56.27±.28	24.1±1.77	2.71±.20	2.62±.05
A	Third	23	138.17±3.40	56.47±.35	24.2±2.41	2.46±.25	2.72±.05

TABLE 9.—Summary of Results With Hens Poorly Fed While Young; Flocks Combined by Years.

Flocks	Year	Number of Fowls	Mean Number of Eggs	Mean Annual Weight of Eggs	Standard Deviation in Number of Eggs	Standard Deviation in Mean Annual Egg Weights	Mean Standard Deviation in Weight of Eggs
B, D, F,	First	88	131.00±2.47	51.19±.22	34.4±1.75	3.01±.15	3.07±.05
B, D	Second	40	146.33±2.62	54.98±.38	24.6±1.86	3.54±.27	2.74±.05
B	Third	21	129.52±3.77	56.36±.50	25.6±2.66	3.38±.35	2.73±.07

The number and the mean weight of the eggs laid by the birds in flocks A and B for the first two years and by the birds in flocks C and D for the pullet year have already been considered in Bulletin 179 of this station. For the purpose of presenting a comprehensive survey of the experiment these data are included and the results are here discussed as a whole.

Number of Eggs Laid

Tables 1 to 9 record only the eggs gathered from the trap nests. Double-yolked eggs and those abnormally small have been disregarded. The actual number of eggs laid by these fowls was between 2 and 3 per cent greater than is shown in the tables, but it is believed that this source of error would have little or no effect upon the mean egg weights or upon the standard deviation as shown in Tables 6, 7, 8, and 9.

During the pullet year the egg production varied from a minimum of 40 eggs laid by bird No. 600 to 208 eggs laid by bird No. 435.

The mean egg production for the pullet year of the birds which were well fed while young was 150.12±2.00 while their poorly fed sisters laid only 131.00±2.47 eggs or a difference of roughly one and one-half dozen eggs per bird. In this connection it should be remembered that after laying began all these birds were fed and handled in exactly the same way. After the first year there was practically no significant difference in the egg production of the two lots of sisters.

Weight of Eggs

In the pullets the mean egg weight varied from a minimum of 42.27±.18 grams (bird 304) to a maximum of 58.85±.20 grams (bird 410) thus giving a difference of 16.58±.27 grams. This difference in mean egg weight is so large that five of the eggs laid by bird 410 would weigh practically the same as seven laid by 304. This is an illustration of the desirability, if not the necessity of selecting and breeding for greater uniformity in egg weight.

Of the 177 fowls there were only seven, Nos. 306, 410, 528, 565, 574, 596, and 600 whose pullet eggs averaged 56 grams or more, and as it is desirable to produce a two-ounce egg selection should be exercised in this strain to increase the mean egg weight. This should not be difficult to accomplish as Atwood (1925) has shown that there is a positive correlation between mean egg weight and mean body weight, hence by disposing of the smaller pullets each fall the egg size would be gradually increased even though no effort were made to breed from the birds laying the larger eggs.

After the first year the eggs were practically of standard weight although those laid by flocks B and D during the second year were a trifle too small.

The mean weight of the pullet eggs laid in this experiment was 51.17±.13 grams; for the second year, 55.62±.23 grams, and 56.41±30 grams for the third year of production. The increase in the weight of the eggs the second year as compared with the first was 4.45±.26 grams; and the increase for the third year as compared with the second was .79±.38 grams. It is evident, therefore, that the eggs attained almost their full weight during the second year of production. Apparently, the different rations fed the growing chickens had no effect upon the weight of the eggs laid.

Standard Deviation in Number and Weight of Eggs

The standard deviation in the number of eggs laid was largest during the pullet year. Comparing the deviations in number of eggs laid by flocks A, C, and E with the deviations for flocks B, D, and F it is seen that these deviations average larger for the latter flocks. In other words, the poor ration fed to the females in flocks B, D, and F seems to have increased variability in respect to the number of eggs laid.

Similarly, too, the standard deviation in the mean annual weight of the eggs was greater in the case of flocks B, D, and F indicating that the poor ration fed to these fowls while young caused them to become somewhat more variable in respect to their mean annual egg weight.

The standard deviation in the weight of the eggs was largest during the pullet year. No significant difference can be observed in the standard deviation in the weight of the eggs resulting from the rations fed the growing chickens.

The mean standard deviation in the weight of White Leghorn eggs, based on 303 annual records of production, namely, 177 annual pullet records, 82 annual yearling hen records, and 44 two-year-old hen records, was 2.97±.03 grams, with a maximum deviation of 6.14±.24 grams and a minimum deviation of 1.52±.09 grams or a variation about four times as great as the minimum deviation.

The mean weight of all of the eggs laid in this experiment based on the means derived from the 303 annual records was 53.14±.14 grams, and the standard deviation of the 303 mean annual egg weights was 3.68±.10 grams.

An inspection of the tables shows that the deviation in the mean annual egg weights for the various females is slightly greater than the deviation in the weight of the individual eggs laid by them.

Uniformity of Mean Egg Weight in Individual Birds

Although the weight of the eggs laid by the same bird fluctuates from day to day and from month to month yet each individual has a characteristic egg weight that remains fairly uniform except that it increases with the age of the bird, and especially during the pullet year. Table 10 shows the correlation between the mean egg weight for the pullet year and the mean egg weight for the second year of production based, on the 82 records which are complete for the two years. Table 11 presents the data for the 44 fowls whose records were complete for the three years.

TABLE 10.—Scatter Diagram of Mean Egg Weights of 82 Fowls for the Pullet Year and the Second Year of Production.

Flocks A, B, C, D Pullets Grams	Flocks A, B, C, D, Yearlings—Grams																	
	48.5	49.5	50.5	51.5	52.5	53.5	54.5	55.5	56.5	57.5	58.5	59.5	60.5	61.5	62.5	63.5	64.5	Total
42.5	1																	1
43.5																		
44.5																		
45.5				1														1
46.5		1		2	1													4
47.5	1		1		1													3
48.5				1	3	3	1	2										10
49.5						4	5	2	1	1								13
50.5					1	2	4	3	2	2	2	1						17
51.5						1		1	3	2	2	1						10
52.5							1	1	2	5	1	3	3					16
53.5									1	1		1	2					5
54.5																		
55.5																		
56.5																		
57.5																	1	1
58.5																	1	1
Total	2	1	1	4	6	10	11	9	9	11	5	6	5				2	82

$r = +.86 \pm .02$

TABLE 11.—Scatter Diagram of Mean Egg Weights of 44 Fowls for the Second and Third Years of Production.

Flocks A and B Second Year Grams	Flocks A and B Third Year—Grams																
	50.5	51.5	52.5	53.5	54.5	55.5	56.5	57.5	58.5	59.5	60.5	61.5	62.5	63.5	64.5	Total
48.5	1															1
49.5	1															1
50.5																
51.5		1	1													2
52.5			1		1	1										3
53.5			2		1											3
54.5					2	5										7
55.5					2		2	1								5
56.5							2	1	2							5
57.5							2	2	3							7
58.5									1	2						3
59.5									1	3						4
60.5										1			1			2
61.5																
62.5																
63.5																
64.5															1	1
Total	2	1	4		6	6	6	4	7	6			1		1	44

$r = +.95 \pm .01$

The coefficient of correlation between the mean annual weight of the eggs laid during the first and second years by the 82 fowls with a record for two years was $+.86 \pm .02$; and for the second and third years for the 44 fowls that had a record for three years was $+.95 \pm .01$. This shows a very high correlation of the mean annual egg weight from one year to another, and it may be stated that the average size of the eggs laid by a hen is a very fixed, definite, and persistent characteristic. On the other hand the coefficient of corre-

lation between the standard deviations in the weight of the eggs of the same fowls for the first and second years was $+.21 \pm .07$ and for the second and third years was $+.44 \pm .08$. In other words the standard deviation in egg weight for any female is a less permanent or persistent character than is the mean egg weight.

THE INFLUENCE OF DIFFERENT RATIONS ON EGG WEIGHT

In order to determine whether the character of the ration fed to laying hens has any appreciable influence on the weight of the eggs laid, and whether the ration that will produce the largest number of eggs will produce eggs of greatest average weight the experiment herein described has been carried out.

This experiment was started November 1, 1923, with six pens of Single Comb White Leghorn pullets hatched May 9, 1923. Each pen contained sixteen birds and the pens were numbered 4 to 9, inclusive.

During November and December scratch feed and laying mash were fed to all pens alike but during the next four months or until May 1, pens 4, 6, and 7 received whole grain only, the laying mash being withheld. After May 1 all six pens were fed alike, laying mash being provided in hoppers and scratch grain fed in straw litter. The scratch feed consisted of 2 parts corn, 2 parts wheat, and 1 part oats. The mash consisted either of Full-o-pep laying mash or a mixture of 2 parts corn meal and 1 part each of wheat bran, red dog, and meat scrap.

Table 12 gives the number and mean weight of eggs laid by each pen during the first year of the test.

TABLE 12.—Number and Mean Weight of Eggs Laid by the Six Pens of White Leghorns During the First Year of the Experiment.

Months and Items Considered	Pen 4		Pen 5		Pen 6		Pen 7		Pen 8		Pen 9	
	Eggs Laid	Mean Weight Grams	Eggs Laid	Mean Weight Grams	Eggs Laid	Mean Weight Grams	Eggs Laid	Mean Weight Grams	Eggs Laid	Mean Weight Grams	Eggs Laid	Mean Weight Grams
November 1923	113		160		86		124		87		161	
December 1923	103		137		65		32		106		153	
January 1924	5		66		23		11		49		58	
February 1924	64		168		56		55		178		184	
March 1924	141	50.32	324	56.36	136	48.54	152	47.59	326	55.15	361	55.00
April 1924	110	49.36	382	55.80	65	47.83	84	46.47	337	54.54	390	54.09
May 1924	315	54.15	348	54.90	258	51.12	269	49.62	341	53.86	395	52.61
June 1924	361	54.57	276	54.75	353	52.53	322	50.98	328	53.46	365	52.29
July 1924	331	54.31	238	54.47	307	52.74	302	50.95	284	53.41	355	52.90
August 1924	294	54.23	187	54.89	292	52.66	260	51.28	208	55.00	239	53.70
September 1924	211	55.47	105	55.37	188	54.43	167	52.49	94	56.22	105	55.30
October 1924	85	56.54	23	56.91	53	56.87	70	54.81	49	56.51	56	54.29
Unweighted mean weight for March and April		49.84		56.08		48.19		47.03		54.85		54.55
Unweighted mean weight for May and June		54.36		54.83		51.83		50.30		53.66		52.45
Gain or loss as compared with March and April		4.52 Gain		1.25 Loss		3.64 Gain		3.27 Gain		1.19 Loss		2.10 Loss

The unweighted mean weight of the eggs laid by pens 4, 6, and 7 for the months of March and April was 48.35 grams, while the unweighted mean weight of the eggs laid by the other pens was 55.17 grams, or a difference in weight due to feeding the unbalanced ration of 6.81 grams or slightly more than 12 per cent. During the next two months when pens 4, 6, and 7 were fed mash the mean weight of the eggs increased 3.81 grams while the eggs from pens 5, 8, and 9 decreased 1.52 grams. This decrease in weight, however, was entirely normal and to be expected as eggs usually are smaller during the summer months.

Withholding the mash from pens 4, 6, and 7 until after May 1 had the effect of holding up the average egg weight after May 1 when under normal feeding it would have fallen. As the heavy egg produces the heavy chick this procedure may be of practical importance whenever it is desirable to produce eggs for hatching late in the season.

Second Year of Test

The experiment was continued during the second year with the same fowls and on the same plan except that pens 5, 8, and 9 were the ones which received no mash during January, February, March and April. Table 13 shows the number and mean weight of the eggs by months.

The results for the second year are in entire agreement with those obtained during the first year, in that the feeding of the ration consisting of whole grain reduced the number and mean weight of the eggs. Later in the season when mash was fed the weight of the eggs laid by these fowls increased while the weight of the eggs laid by the comparative lots decreased. It is consequently evident that the size of the eggs depends to a certain extent upon the character of the ration provided for the layers.

TABLE 13.—Number and Mean Weight of Eggs Laid by the Six Pens of White Leghorns During the Second Year of the Experiment.

Months and Items Considered	Pen 4		Pen 5		Pen 6		Pen 7		Pen 8		Pen 9	
	Eggs Laid	Mean Weight Grams	Eggs Laid	Mean Weight Grams	Eggs Laid	Mean Weight Grams	Eggs Laid	Mean Weight Grams	Eggs Laid	Mean Weight Grams	Eggs Laid	Mean Weight Grams
November, 1924	28	59.93	30	59.67	19	57.37	16	54.05	21	58.71	26	58.35
December, 1924	8	58.00	4	60.50	24	57.29	12	56.75			7	55.43
January, 1925	43	60.65	6	60.67	23	57.52	26	55.62	2	54.50	7	52.29
February, 1925	81	60.28	33	56.52	96	56.47	59	55.42	36	54.53	42	55.57
March, 1925	189	57.86	69	54.39	298	57.26	176	55.64	82	54.38	121	55.37
April, 1925	352	57.49	115	52.26	342	56.08	311	54.45	152	53.14	232	53.69
May, 1925	343	56.94	235	55.44	351	55.83	338	54.22	289	54.51	307	54.61
June, 1925	310	55.43	278	54.40	345	54.35	303	53.06	320	54.12	343	54.47
July, 1925	310	55.63	193	54.43	340	54.31	323	53.29	307	54.39	321	55.34
August, 1925	261	56.08	163	54.67	274	54.62	275	54.06	265	55.14	211	55.87
Unweighted mean weight for March and April		57.68		53.33		56.67		55.05		53.76		54.53
Unweighted mean weight for May and June		56.18		54.92		55.09		53.64		54.31		54.54
Gain or loss as compared with March and April		1.40 Loss		1.59 Gain		1.58 Loss		2.41 Loss		.55 Gain		.01 Gain

A COMPARISON OF THE WEIGHTS OF THE EGGS IN A CYCLE, WITH REFERENCE TO NUMERICAL PRODUCTION

When a bird lays without interruption for two or more days in succession and then ceases to lay for one or more days, the eggs thus laid in succession are termed a cycle.

It has been pointed out by Curtis (1914) and also by Atwood and Weakley (1917) that as a rule the eggs in a cycle decrease in weight from the first egg toward the last egg of the series, the next cycle beginning with a heavy egg and so on. This general rule is illustrated by Table 14 which gives the date of laying and the weight of the eggs laid by Bird 322 for May, 1923.

TABLE 14.—Record of Eggs Laid by Bird No. 322 for May, 1923.

Day of Month	Weight of Egg in Grams	Day of Month	Weight of Egg in Grams	Day of Month	Weight of Egg in Grams
1	61.28	11	56.85	21	57.42
2	59.16	12	57.35	22	56.92
3	57.34	13	58.52	23	55.68
4	57.42	14	none	24	none
5	54.37	15	61.71	25	59.10
6	59.97	16	59.13	26	57.71
7	57.78	17	59.60	27	55.68
8	58.78	18	60.13	28	56.45
9	none	19	none	29	none
10	61.93	20	59.02	30	60.66
				31	58.50

It is to be observed that there is not a perfectly regular decrease in egg weight from day to day. In the first cycle the egg laid on May 6 was heavier than the egg laid May 2, and there were only three eggs which were larger than the last egg of the cycle. In the next cycle the eggs laid on the 12 and 13 were each heavier than the egg laid on the 11. In the cycle beginning May 20, each egg in the series is smaller than the egg which immediately precedes it, thus agreeing with the general rule, but the decrease in weight varies considerably being 1.60, .50, and 1.24 grams per egg. It is therefore evident that in these cycles there is no great amount of regularity in the decrease in egg weight from day to day. In fact, other instances could be easily cited in which the egg weight is much more variable than in the case given. Nevertheless, when a sufficiently large number of records is examined, the truth of the general law that there is a progressive decrease in the weight of the eggs in a cycle becomes clearly evident.

In Table 14 there are six cycles. The average decrease in the weight of the eggs in a cycle may be calculated from the formula $\frac{A-L}{N-1}$ in which "A" represents the weight of the first egg of the series "L" the weight of the last egg and "N" the number of eggs. For example, in the first cycle, the mean decrease is .357 grams. The mean decrease for a number of cycles may be calculated by the formula $\frac{\Sigma(A-L)}{\Sigma(N-1)}$. Making the necessary calculations for the six cycles in Table 14 one finds $\frac{\Sigma(A-L)}{\Sigma(N-1)} = \frac{15.64}{20}$ or a mean decrease of .782 grams per egg.

Fowls Employed

The fowls whose eggs were used in this work were single comb White Leghorns. They were in flocks A, B, C, D, E, and F, to which reference has already been made in this bulletin. For the purposes of this study they may be considered as a random sample of White Leghorns.

Table 15 gives the number of birds whose records are included for each month; the mean decrease in the weight of the eggs in the cycles; the mean number of eggs laid per month; and the coefficient of correlation between the mean decrease per egg and the number of eggs laid per month for the birds in flocks A and B during their third laying year.

Table 15 shows that the mean decrease in the weight of the eggs in the cycles ranged from a maximum of 2.828 grams in October to a minimum of 1.430 grams in May.

The coefficients of correlation with the exception of that for February, are all negative and they are significant for the months of June, August, September, and October. On account of the fact that in October there were only six hens with enough cycles so that their records could be used, too much stress should not be laid on the relatively high correlation for that month.

The coefficients of correlation indicate that the greater the rate of egg production, the smaller is the decrease in the weight of the eggs in the cycles.

Table 16 derived from Table 15 shows the mean decrease in the weight of the eggs in the cycles, the mean number of eggs produced each month and the percentage daily egg production per month for flocks A and B during their third laying season.

TABLE 15.—Number of Eggs Laid; the Mean Decrease in Their Weight; and the Correlation Between Number of Eggs Laid and Mean Decrease in Weight for Flocks A and B During Nine Months of Their Third Laying Year.

Items Considered	February	March	April	May	June	July	August	September	October
Number of birds included	24	43	44	44	41	41	37	30	6
Mean decrease in weight per egg—grams	2.559	2.111	1.453	1.430	1.631	1.446	1.874	2.218	2.828
Mean number of eggs laid per month	8.87	18.80	20.43	20.73	18.46	20.32	19.16	14.96	14.16
Correlation between decrease in weight per egg and number of eggs laid. r=	+.120±.135	—.215±.098	—.051±.101	—.229±.096	—.424±.086	—.287±.097	—.430±.090	—.423±.101	—.821±.090

TABLE 16.—Mean Decrease in Weight of Eggs in Cycles, Mean Number of Eggs per Month, and Percentage Daily Production per Month for Flocks A and B during Third Laying Season.

Months	Mean Decrease in Weight of Eggs in Cycles; Grams	Mean Number of Eggs Laid per Bird per Month	Per Cent Daily* Production
February	2.56	8.87	31.7
March	2.11	18.80	60.6
April	1.45	20.43	68.1
May	1.43	20.73	66.9
June	1.63	18.46	61.5
July	1.45	20.32	65.5
August	1.87	19.16	61.8
September	2.22	14.96	49.9
October	2.83	14.16	45.7

*Obtained by dividing the mean number of eggs laid per month, by the number of days in that month, and then multiplying the quotient by 100.

The unweighted mean decrease in the weight of the eggs during the nine months was 1.950 grams. The correlation between the decrease in weight and the per cent daily egg production was, $r = -.873 \pm .053$. Consequently, it is plainly evident that there is a relatively high degree of relationship between the decrease in the weight of the eggs in the cycles and the rate of production.

Table 17 gives the results of other correlations that have been calculated between the decrease in egg weight and the annual production.

The unweighted mean decrease in the weight of the eggs laid by the fowls whose record is shown in Table 17 was 1.11871 grams. This is a smaller decrease in the weight of the eggs in cycles than is shown in Table 15 with three year old hens, and inasmuch as the yearling hens in Table 17 show a greater decrease than the same birds when pullets, it appears probable that the extent of the decrease in the egg weight becomes greater as the fowls grow older.

TABLE 17.—Correlations Between Decrease in Weight and Annual Production.

Flocks	Number of Fowls	Age of Fowls	Decrease Computed for	Mean Decrease in Weight of Eggs Grams	Mean Annual Egg Production	Correlation Between Decrease and Annual Production
E	46	Pullets	Apr., May, June	1.00087	155.891	—.156±.097
F	45	Pullets	Apr., May, June	1.06622	142.933	—.059±.100
CD	38	Pullets	Apr., May, June	1.06500	134.184	—.365±.095
AB	42	Pullets	May, June	1.14286	135.283	—.485±.079
AB	43	Yearling	Apr., May, June	1.31860	150.442	+.035±.103

In Table 17 four of the five coefficients of correlation are negative. Two of the coefficients are significant and these results considered in connection with those given in Tables 15 and 16 indicate that the better the production the smaller is the decrease in the weight of the eggs in the cycles. This general principle is probably based on the physiological processes of the birds, and may represent a certain degree of fatigue or exhaustion of the reproductive organs when called upon to produce material for the daily egg. From these results it would appear that if the egg producing organs are easily fatigued so that there is a decided drop in the amount of egg substance produced from day to day, then the number of eggs laid will be at a low ebb.

TABLE 18.—Weight of Eggs Laid During May, 1923, by Bird 587. in Her Pullet Year.

Day of Month	Egg Weight	Day of Month	Egg Weight	Day of Month	Egg Weight
1	46.26	11	none	21	56.50
2	none	12	55.45	22	55.89
3	51.50	13	56.03	23	none
4	52.67	14	none	24	none
5	none	15	54.68	25	none
6	53.12	16	54.93	26	none
7	54.64	17	none	27	none
8	none	18	54.59	28	none
9	55.80	19	none	29	none
10	55.82	20	none	30	none
				31	none

With some birds the egg weight fluctuates in an unaccountable manner. Table 18 presents a case in which there are six two-egg cycles. In every instance except the last the second egg is heavier than the first.

Table 19 also presents a record in which the egg weights fluctuate widely.

TABLE 19.—Weight of Eggs Laid by Bird 567 During April, 1923.

Day of Month	Egg Weight	Day of Month	Weight Egg	Day of Month	Egg Weight
1	43.98	11	50.78	21	52.21
2	none	12	38.92	22	46.39
3	none	13	41.81	23	40.94
4	none	14	42.96	24	none
5	47.46	15	39.34	25	51.08
6	none	16	47.30	26	none
7	47.97	17	none	27	39.81
8	52.40	18	40.34	28	45.28
9	49.18	19	48.93	29	47.68
10	none	20	none	30	46.70

The weight of the eggs as shown in Table 19 is even more variable than those shown in Table 18. What causes these fluctuations? This question opens an attractive field for the study of the influence upon egg weight of various environmental factors, each of which may have an influence upon the weight as well as upon the number of eggs. **If the way can be pointed out for a more uniform production of egg substance from day to day this should pave the way for higher egg records.**

The results of this investigation indicate that the smaller the mean daily decrease in the weight of the eggs in the cycle the greater is the rate of egg production, also that the weight of the eggs in the cycle varies widely with many individuals and further study is needed to determine the reason for these fluctuations.

THE RESEMBLANCE OF SISTERS IN RESPECT TO THE MEAN WEIGHT OF THEIR EGGS

In breeding poultry for the production of eggs of more uniform size, it is important to know whether the mere selection of dams that lay eggs of the proper size will tend toward the production of progeny having the desired characteristics. In other words, do full sisters resemble each other more closely in respect to the size of their eggs than do the unrelated females of the same flock.

Source of Data Used

The mean annual weight of eggs laid during the pullet year by 177 White Leghorns is reported in Tables 1 to 5, inclusive, to which reference is here made for details regarding these fowls. The sires

of the birds in flock AB were nine not closely related males of unknown ancestry and about the same number of not closely related males were used in the production of flocks CD and EF.

Table 20 is inserted to show the method of analyzing the data and gives the record for flock CD for the pullet year.

TABLE 20.—Comparison of Birds in Flock CD Arranged in Families of Sisters.

Sisters	Mean Egg Weight	Average Egg Weight of Sisters	Departure From Average	Random Sample	Mean Egg Weight	Average Egg Weight	Departure From Average
403	53.0	51.90	1.10	439	50.7	50.60	.10
440	50.8		1.10	407	50.5		.10
411	52.4	50.55	1.85	435	52.9	51.95	.95
426	48.7		1.85	436	51.0		.95
434	50.3	50.20	.10	403	53.0	52.20	.80
428	52.5		2.30	422	52.3		.10
439	50.7		.50	409	52.7		.50
441	47.3		2.90	438	50.8		1.40
401	48.3	50.20	1.90	419	50.2	50.37	.17
402	52.5		2.30	408	46.7		3.67
404	51.2		1.00	424	51.8		1.43
427	48.8		1.40	432	52.8		2.43
424	51.8	50.25	1.55	413	49.5	51.20	1.70
418	48.7		1.55	442	52.9		1.70
435	52.9	51.80	1.10	431	51.5	50.10	1.40
405	50.7		1.10	418	48.7		1.40
406	49.6	50.67	1.07	405	50.7	53.07	2.37
420	52.9		2.23	406	49.6		3.47
413	49.5		1.17	410	58.9		5.83
415	45.8	48.13	2.23	416	50.5	49.70	.80
437	51.2		3.07	443	47.4		2.30
443	47.4		.73	404	51.2		1.50
407	50.5	54.70	4.20	415	45.8	48.30	2.50
410	58.9		4.20	440	50.8		2.50
409	52.7	50.55	2.15	426	48.7	49.95	1.25
421	48.1		2.45	401	48.3		1.65
432	52.7		2.15	423	49.8		.15
442	52.9		2.35	434	50.3		.35
408	46.7		3.85	425	50.2		.25
425	50.2		.35	411	52.4		2.45
431	51.5	50.77	.73	429	52.1	50.20	1.90
423	49.8		.97	437	51.2		1.00
436	51.0		.23	441	47.3		2.90
422	52.3	51.40	.90	402	52.5	52.70	.20
416	50.5		.90	420	52.9		.20
419	50.2	51.03	.83	421	48.1	49.80	1.70
438	50.8		.23	427	48.8		1.00
429	52.1		1.07	428	52.5		2.70

In Table 20 the birds in flock CD are arranged in families as shown in the first column. For example birds 403 and 440 were sisters, and so on. The second column shows the mean annual egg weights for the pullet year for each bird; column three gives the average of the mean egg weights for each family; column four shows the departure or variation in the mean egg weight for each bird from the average for the family; column five shows the birds arranged at random in groups of similar size to the families shown in column one, and columns six, seven, and eight correspond respectively to columns two, three, and four.

Table 21 shows the mean departure in egg weight of the birds from the average egg weight of the families to which they belong together with the standard deviation of these departures calculated for flocks AB, CD, and EF.

TABLE 21.—The Mean Departure and Standard Deviation in Egg Weight of Sisters, Compared with the Results from "Families" Consisting of Individuals Chosen at Random.

Items Considered	Flock AB	Flock CD	Flock EF
Number of birds	44	38	91
Number of families	14	13	29
Mean departure of sisters from average for the family	1.51±.12	1.63±.11	1.65±.08
Mean departure of "random sample" from average "for the family"	1.67±.13	1.52±.13	1.66±.09
Standard deviation of departures for sisters	1.20±.08	1.04±.08	1.18±.06
Standard deviation of departures for random sample	1.31±.09	1.21±.09	1.29±.06

There was no significant difference in the variability of the sisters in the same family as contrasted with each other, as compared with the variability of individuals chosen at random and thrown into similar "families". The data apparently justifies the conclusion that in order to obtain daughters having a reasonably uniform egg weight the mere selection of dams having the desired egg weight will not be sufficient for the purpose.

GENERAL SUMMARY

1. The birds whose individual records have been considered differed widely not only in respect to the number of eggs laid, but also in respect to the mean weight or average size of their eggs. The number of eggs laid in one year varied from 40 to 214, and the mean annual egg weight varied from 42.27±.18 grams to 64.65±.17 grams.

2. The rations which brought about a slow growth in the birds in flocks B, D, and F had the effect of reducing the number of eggs laid by these birds, particularly during the pullet year, but did not affect the size of the eggs.

3. The rations supplied to the birds in flocks B, D, and F while the birds were young seemed to have the effect of increasing variability, both in respect to the number of eggs laid and their weight.

4. The mean standard deviation in the weight of the White Leghorn eggs considered in this study was approximately 3 grams and varied from a minimum of 1.52±.09 grams to a maximum of 6.14±.24 grams.

5. The eggs attained almost their full weight during the second laying season. The increased weight for the second year as compared with the weight for the pullet year was approximately 9 per cent.

6. The average size of the eggs laid by a bird is a fixed definite and persistant characteristic.

7. The size of eggs depends, in part at least, upon the character of the ration fed. A ration consisting of whole grain only fed in winter reduced the weight of the eggs about 12 per cent.

8. As a rule, the greater the productive capacity of a bird, the smaller is the average decrease in the weight of the eggs which are laid on consecutive days.

9. During the period of maximum production, the decrease in the weight of the eggs laid on consecutive days is at a minimum.

10. With many birds, egg weight fluctuates from day to day in an unaccountable manner and further study of the reasons for these fluctuations is desirable.

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